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(12) UK Patent Application (19) GB (11) 2 206 403 (13) A

(43) Application published 5 Jan 1989

(21) Application No 8811552

(22) Date of filing 16 May 1988

(30) Priority data
(31) 8711565 (32) 15 May 1987 (33) GB

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(51) INT CL⁴
F28D 17/00

(52) Domestic classification (Edition J):
F4K 24B2 24B3 27 29

(56) Documents cited
GB 1501174 GB 1415776 GB 1281782
GB 0786254

(58) Field of search
F4K

(54) **Thermal regenerators**

(57) A method of employing a regenerative burner to supply hot gas to a user comprises causing the hot products of combustion to issue from the burner 2 towards the regenerator 14 and subsequently passing a gas stream through the thus-heated regenerator 14 towards the user via the burner 2. The method may employ two burners in push-pull arrangement, and the burners may be intermittently or continuously fired. Alternative embodiments provide for situations where the user can and cannot tolerate products of combustion.

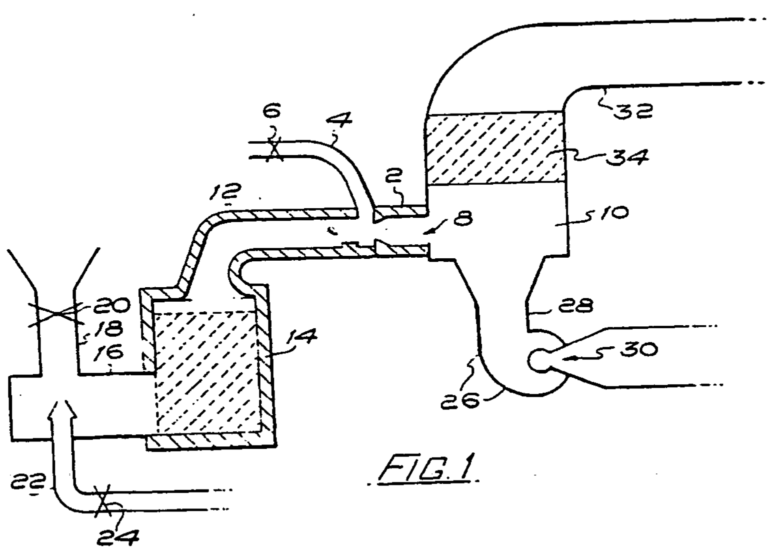

FIG. 1

The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

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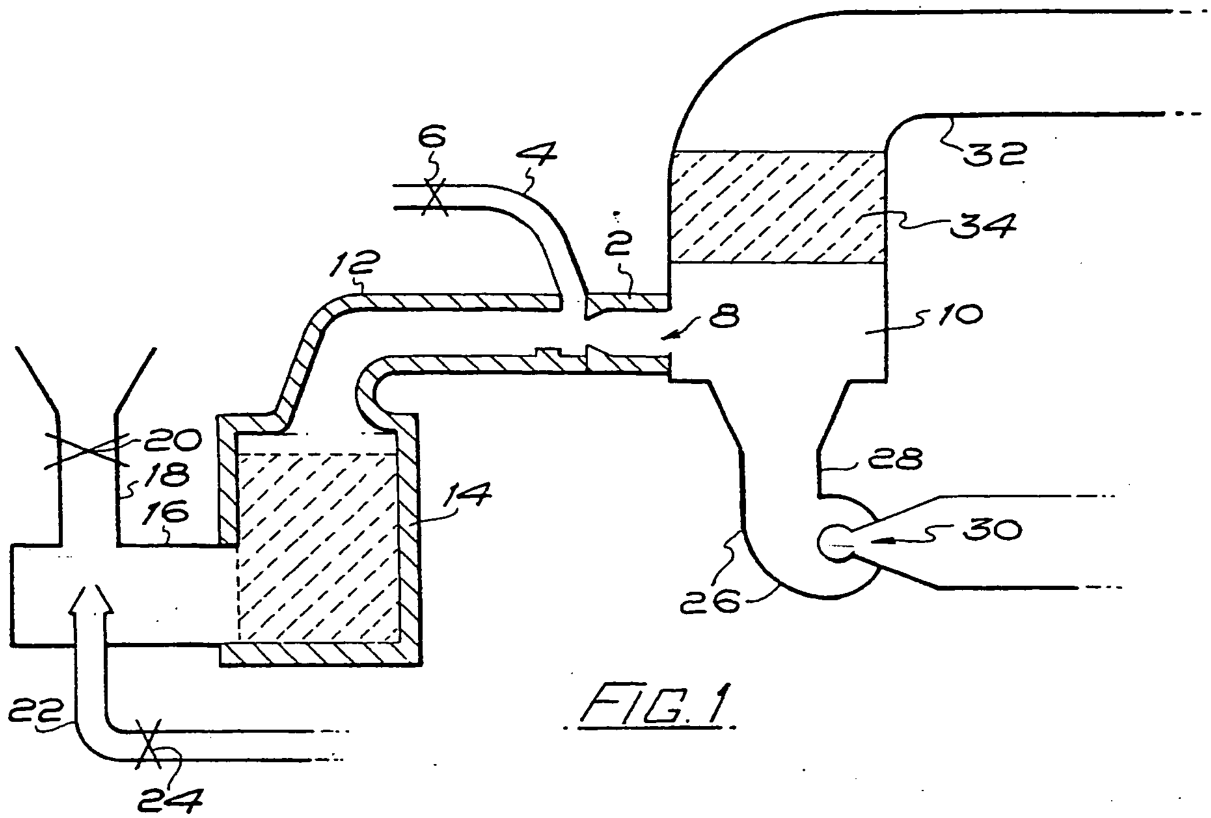
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FIG.1

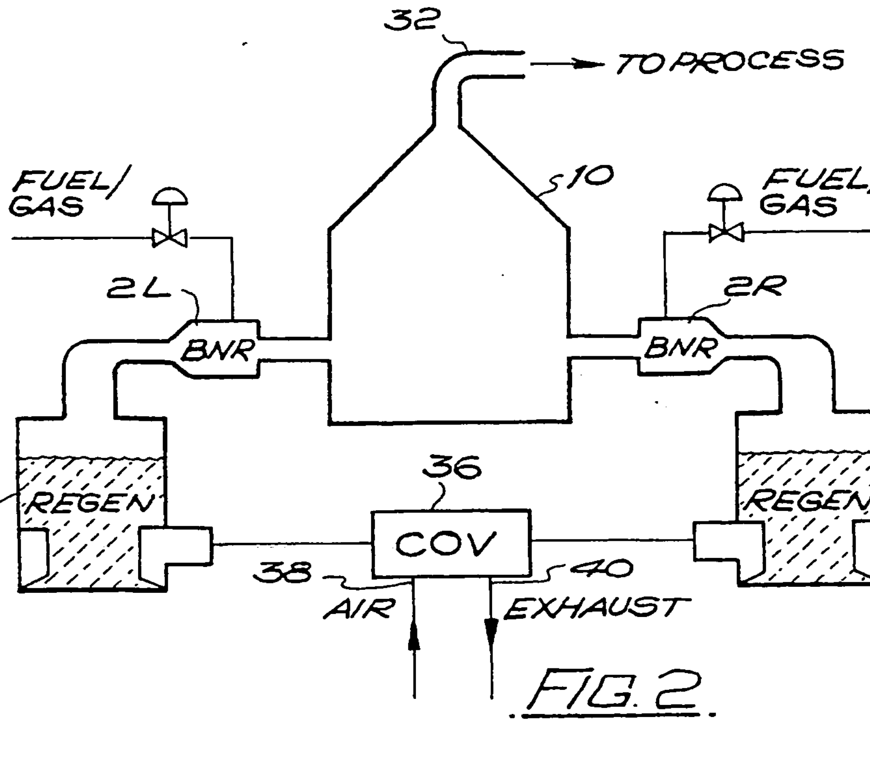
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FIG.2

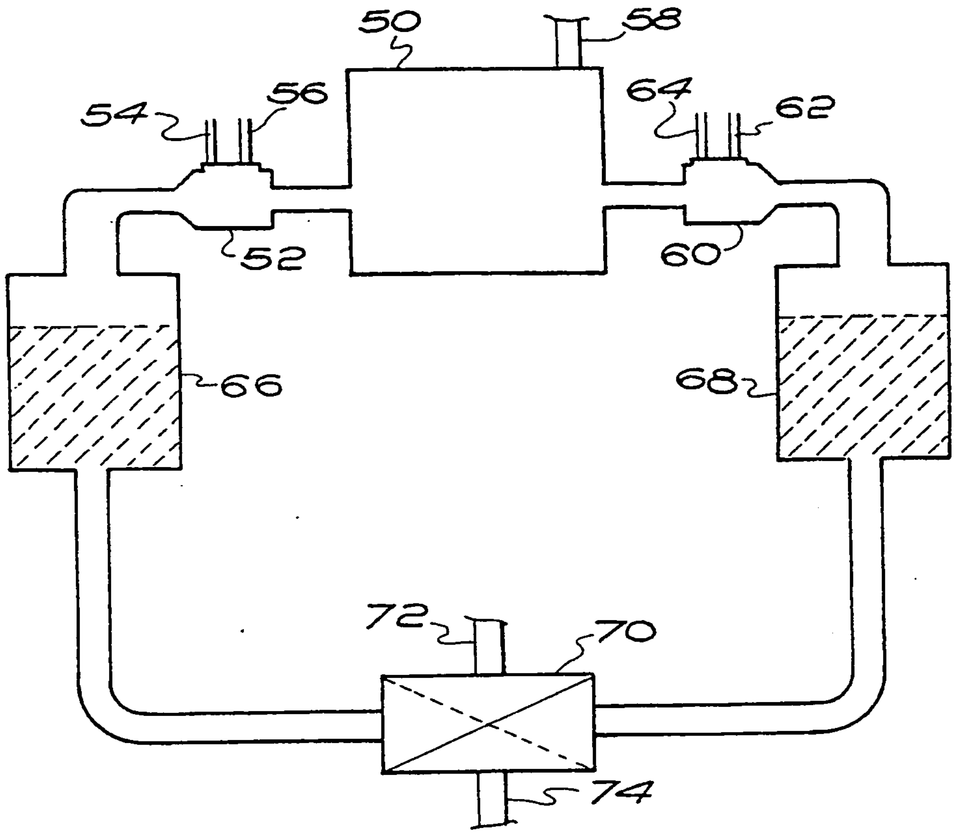

FIG. 3

Hot Air Generators

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The invention relates to apparatus for the production of hot gas, primarily but not exclusively air, for industrial process heating or possibly space heating.

It is important at least for space-heating and possibly also for certain industrial processes, that the hot air shall be free from harmful constituents, and this requirment has militated against the use of such devices as gas burners, in spite of their economic attraction. In other industrial processes this requirement is not so critical and to some extent the products of combustion of fuel gases can be tolerated, but cost of fuel and installations make severe demands on operational conditions.

It is known to provide heat for furnaces and the like by burning a combustible material, such as a fuel gas, in air, and introducing the hot products of combustion into the furnace. It is also known from British Patent 2128724 to withdraw hot waste gas, including such products of combustion, from such a furnace into a regenerator or other form of heat-exchanger so as to absorb heat from the gas, to discharge the thus-cooled gas and then to pass air though the regenerator so that it may be heated by the thus-absorbed heat and to use the heated air in the combustion of fuel gas in a burner adapted to heat the furnace, whereby some of the thermal energy of the waste gas is retained within the system so as to increase the efficiency thereof. Attention has not, however, similarly been given to the efficient provision of hot air, with the products of combustion reduced or eliminated, for space-heating or for industrial processes.

According to one aspect of the present invention, therefore, there is provided apparatus for the supply of hot air comprising at least one burner for the combusion, in air, of a combustible fluid, the or each said burner having first and second gas ports, a regenerator in fluid connection with the or each burner by said first port, means for discharging the products of said combustion through said first port or ports and conveying them through said regenerator or generators and thence to waste, and means for subsequently passing air through the or each regenerator and into and out of the or each burner respectively by said first and second ports.

The apparatus may comprise two burners arranged so that whilst products of combustion are being discharged from either one and through its associated regenerator, air is being passed through the regenerator associated with the other and thence into and out of said other burner. The burners may be connected to a common exhaust outlet and to a common air inlet.

Preferably the apparatus also comprises means for controlling the supply of combustion fluid to the or each burner. The apparatus may further comprise timing means for controlling the sequential movement respectively of products of combustion and of air through the or each regenerator. The timing means may further control the supply of combustion fluid to the or each burner.

According to a further aspect of the invention there is provided a method of supplying hot air comprising combusting a combustible fluid in air in at least one burner (the or each said burner having first and second gas ports), discharging the products of said combustion through said first port or ports and conveying them through a regenerator in fluid connection with the or each burner and thence to waste, and subsequently passing air through the or each regenerator and into and out of the or each burner respectively by said first and second ports.The air subsequently passed through the or each regenerator may be contaminated air derived from environs of an industrial process.

When the method uses a single burner, products of combustion may continue to be passed through the regenerator and discharged to waste after such products have stopped being produced. When the method employs two burners, products of combustion are preferably produced by each in turn with air being passed into and out of the other.

Embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, of which:

Fig. 1 is a schematic side elevation of regenerative heating apparatus in one embodiment, and

Fig. 2 is a schematic side elevation of regenerative heating apparatus for continuous operation.

Fig. 3 is a schematic side elevation of regenerative heating apparatus in a further embodiment.

Referring first to Fig. 1, a gas burner 2 is arranged to be supplied with fuel gas via a supply pipe 4 subject to control by a valve 6. By means of an eductor system to be described below, combustion air is supplied to the burner from a chamber 10 via port 8, and products of combusion of the gas in the air are conveyed along an insulated passage 12 to a regenerator 14, which comprises a heat-storage bed having through channels and enclosed within an impermeable, heat-insulating housing. Such regenerators are known, per se, from, for example, British Patent 2128724.

The channels of the regenerator 14 lead from the passage 12 to a duct 16 which in turn connects with an outlet pipe 18 controlled by a non-return valve 20, and an air-inlet pipe 22 controlled by valve 24. Externally of the valve 24 is a relatively low-pressure fan (not shown) and the pipe 22 extends internally of the duct 16 to provide a Venturi effect.

To one side of the port 8 the chamber 10 is connected by means of ducting 28 to a low-pressure fan 26 which is provided with an inlet port 30. To the other side of the port 8 the chamber connects to a duct 32 by which hot air can be directed from the chamber 10 to where it is required. The end of the duct 32 which connects to the chamber 10 is filled with a heat-absorbing packing 34 which is permeable to the hot air but which imposes a pressure drop thereon.

In use of the apparatus described, valve 6 is opened to allow fuel gas, under pressure, to enter the burner through pipe 4. With the valve 20 open, the fan externally of the valve 24 is operated to blow air through the pipe 22 and out through pipe 18. The extension of pipe 22 has a venturi effect whereby, as is well known, the air passing out of the extension into the duct 16, creates a negative pressure in the duct. Consequently, air introduced into the chamber 10

by the fan 26 is drawn through the burner 2 and regenerator 14. The fuel entering the burner is ignited by conventional means not shown and burns in the air thus drawn from the chamber 10, and the hot products of combustion are conveyed through the regenerator 14, to which they give up some of their heat, before being discharged to atmosphere, together with the induction air, through valved outlet 18.

As gas continues to be burned in the burner, and the hot combustion products continue to pass through the regenerator, the temperature of the heat-absorbing bed increases, though not without limit. When the temperature of the bed, as measured by a temperature probe mounted in the regenerator, reaches a value dictated by experience as representing the optimum, the valve 6 is closed so that no further fuel is fed to the burner and combustion stops. The valve 20 remains open for a further period, however, to allow a continuation of the induction of air through the regenerator so that it can be purged of residual combustion products. This period can again be determined by experience, although the invention also contemplates providing a probe in the pipe 18 for the measurement of, say, carbon dioxide, and keeping the valve 20 open until the probe indicates an acceptably low CO_2 content.

After this period, the valve 6 remaining closed, air continues to be blown into the duct 16 via the inlet pipe 22 but now the valve 20 is closed so that the air must pass through the heated bed of the regenerator 14 in the opposite direction. The bed gives up its heat to the air, thereby increasing the temperature of the air and reducing that of the bed. The heated air is then passed through the burner, in the opposite direction to that in which combustion air passed when the burner was firing, and enters chamber 10 through port 8. The pressure of the air passing into the chamber from the burner is greater than the pressure exerted by the fan 26, so no air is introduced during this phase from the port 30.

The hot air is then driven through the packing 34 and along the duct 32 to where is it required. Some of the heat is dissipated into the packing 34, but nevertheless the temperature of the air leaving the packing can be arranged to have almost any required value subject to the maximum temperature that can be achieved in the regenerator.

As the passage of air through the regenerator 14 continues in the direction just mentioned, however, the regenerator bed cools down, and the rise in temperature of the air diminishes. To a certain extent this is compensated for as the air passes through the packing 34, as heat initially dissipated into the packing from the air passing through begins to return to the air. After a time, however, the temperature of the air leaving the packing reduces to a minimum acceptable level, and the flow in this direction is stopped.

At this time, the valves 12 and 6 are opened up again, the burner 2 is re-ignited, and the cycle recommences as previously described with the difference, at least from the first cycle in any period, that the bed of the regenerator will not be completely cold when combustion products begin the pass through it, and the time to heat it to its optimum can be expected to be somewhat less.

A particularly advantageous feature of the apparatus described above resides in the fact that the inlet 30 of the fan 26 can be arranged either to receive atmospheric air or, if required, contaminated air from an industrial process. In the latter case, any contaminants in the input air which are not destroyed during combustion in the burner

are eventually discharged from the system via pipe 18, along with the products of combustion, and do not contaminate the air which is passed along the duct 32. A multiple of units of burner plus regenerator may be connected to chamber 10 giving the possibility of more continuous heat supply to duct 32.

Referring now to Fig. 2, there is shown apparatus comprising two burners, 2L and 2R, each in communication with a chamber 10 which leads to a duct 32. The burners are in fluid connection with regenerators 14L and 14R, respectively, which in turn are connected to a change-over valve 36 which has an air inlet port 38 and an exhaust port 40. In the first phase of the operating cycle, gaseous fuel is supplied to one of the burners, say burner 2L. The valve 36 is arranged so that the regenerator 14L is connected to exhaust port 40, and regenerator 14R is connected to inlet port 38. Fans, not shown, are arranged outside the ports 38, 40, so as to force air from the environment of the valve 36 through regenerator 14R and burner 2R and into chamber 10. Some of this air then passes into burner 2L where it supports the combustion of the gas supplied to that burner, and the hot combustion products pass through the regenerator 14L and valve 36, leaving the system by port 40. During this phase, the temperature of the packing in regenerator 14L increases.

When the temperature increase has reached a suitable level, the fuel supply to burner 2L is stopped but the air flow is maintained for a period to purge the regenerator 14L of noxious gases. Thereafter, the fuel supply to the other burner, 2R, is turned on and the valve 36 reversed. Fresh cold air from port 38 now passes through regenerator 14L, becoming heated up as heat transfers to it from the hot bed. Some of the now-hot air is or may be extracted from the

chamber for its required application, while burner 2R, ignited by conventional means, burns the fuel supplied thereto in the rest of the hot air. The products of combustion, containing more heat than those of the first phase described because of the hot input to the firing burner, are passed through the regenerator 14R and so to valve 36 and exhaust through port 40.

Because the exhaust gases are hotter than in the first phase, regenerator 14R heats up more quickly or, given time, to a higher temperature than regenerator 14L in the first phase. The duration of the firing of burner 2R is controlled as required, and when it is terminated, the valve 36 reverses again and the cycle repeats are already described with the difference that as each burner begins to fire it is fed with combusion air raised to a higher temperature than before.

The temperature of the air introduced into the system through the port 38 is thus successively heated by the beds of the regenerators 14R and 14L and passed through an inoperative burner into the chamber 10. This hot air is extracted from the chamber as required for space or process heating, being replaced by excess air introduced into the system from the port 38. The burner operative cycle is controlled as required, in consideration of the maximum effective temperature of the regenerators, so that the air in the chamber 10 reaches the required value in accordance with the rate of the extraction.

Fig. 3 shows an embodiment in which the furnace 50 is required to operate at a temperature of, say, 600°C. The furnace is connected to a gas burner 52 which has a gas supply 56 and an air supply 54 and an exhaust outlet 58. If the burner is operated with gas and air supplied in a

stoichiometric mix, the flame temperature would be in the region of 1700°C, but it is possible to reduce this to the required temperature by feeding in a greater amount of cold air than required for combustion, and discharging through outlet 58 a mixture of products of combustion and unreacted oxygen. However, the mixture would be hot and represents a waste of costly energy.

The furnace, therefore, is also provided with a further burner 60, with gas supply 62 and air supply 64, and the burners 52 and 60 are respectively connected to regenerators 66 and 68. As in the Figure 2 embodiment, the regenerators are connected to a control valve 70 by which they can be connected respectively to air supply 72 and exhaust 74, or vice versa.

In use of the apparatus, and in a first cycle of operations, the burner 52 is fired to burn gas introduced by supply 56 in air supplied in excess of stoichiometric requirements, from air supply 64 via control valve 70, augmented if necessary by air from supply 54. The products of combustion, diluted and cooled by the excess air, are passed into the furnace 50 to perform the required heating operation. It is to be understood that for some operations the term "furnace" may not be the most appropriate and in other embodiments the hot air may be introduced into some other type of heating chamber.

The flow of hot gases into the furnace is created by venting the furnace not, however, through exhaust port 58 but by virtue of exhaust fan 74 which is connected to the furnace via valve 70, regenerator 68 and burner 60, and consequently

the mixed gases, reduced in temperature by yielding some heat to the process but still hot, enter the burner 60. As they enter, fuel gas is added from supply 62 and the burner is fired so that the fuel gas burns in the oxygen component of the gas mixture and an even hotter, but less oxygen-rich mixture of gases is passed through the regenerator 68, raising the temperature of the heat-storage material contained therein. The products of the combustion in the two burners, together with any unreacted components of the introduced air are then vented to atmosphere by fan 74 via control valve 70.

When the temperature in the regenerator 68 has risen to an optimum value, as judged by experience, the control valve 70 is reversed, terminating the first cycle and causing air to be introduced into the burner 60 via the control valve 70 and the regenerator 68, and the system to be vented to exhaust 74 via burner 52 and regenerator 66 so that the flow of gases through the furnace and burners is reversed relative to that in the first cycle.

As fresh air passes through the regenerator 68 some of the heat in the latter is transferred to the air so that it enters burner 60 at elevated temperature. Burner 60 remains in a fired condition, the gas which continues to be fed to it by supply 62 burning in the heated air which may be augmented if necessary via supply 64 to ensure excess oxygen. The burning gas provides heat for the process in the furnace, tempered by the excess air, as the gas mixture passes through the furnace into the burner 52. This also remains fired and provided with fuel gas and the combustion of this fuel uses up at least some of the excess oxygen. In this cycle the heat from the burner 52 is directed immediately to the regenerator 66 and the spent gases are vented via exhaust fan 74.

The second cycle ends when regenerator 66 reaches optimum temperature, and the valve 70 is again reversed to begin a further sequence of cycles substantially reproducing, successively, the first and second cycles described above; it will be understood, however, that the next cylce differes from the first in that this time the regenerator 66 is hot and the air introduced to burner 52 is heated thereby beofre combustion.

Significant advantages follow the continuous operation of the two burners, temperature control can be effected by varying the fuel and air inputs,and fuel efficiency is ensured by venting to atmosphere only gases which have yielded most of their heat to the regenerators. Whilst the gases in the furnace include combustion products these are always diluted by air in some excess.

In the above description it has been assumed that the exhaust gases from the fan 74 are voided, but although they are relatively cool they do contain some heat, and if the process can tolerate the substantial proportion of products of combustion contained in those gases, the apparatus described can be modified by dispensing with the air supply 72 and connecting both sides of the control valve 70 to fan 74 which now feeds exhaust gases rather than fresh air into the system and voids only sufficient gas to balance gas input to the system. Any residual oxygen in the exhaust gases is thus consumed at a subsequent buring. In this modification of the apparatus, because of the lack of the air supply 72, all the air input to the system is provided by supplies 54 and 64.

Claims.

1. Apparatus for the supply of hot air to a user comprising at least one burner for the combustion, in air, of a combustible fluid, the or each said burner having first and second gas ports, a regenerator in fluid connection with the or each burner by said first port, means for initially directing the products of said combustion through said first port or ports and conveying them through said regenerator or generators, and means for subsequently passing gas through the or each regenerator and into the or each burner respectively by said first port or ports and out of the or each burner to the user by the second port or ports.

2. Apparatus according to Claim 1 and comprising a single burner arranged so that the combustion products passed through the regenerator are discharged to waste.

3. Apparatus according to Claim 1 and comprising two burners arranged so that whilst products of combustion are being discharged from either burner and through its associated regenerator, air for the combustion in the said burner is being passed through the regenerator associated with the other burner and thence through said other burner.

4 Apparatus according to Claim 1 or Claim 3 wherein the burners are connected to a common exhaust outlet.

5 Apparatus according to any preceding Claim wherein the apparatus also comprises means for controlling the supply of combustion fluid to the or each burner.

6 Apparatus according to any preceding Claim wherein the apparatus further comprises timing means for controlling the sequential movement respectively of products of combustion and of air through the or each regenerator.

7 Apparatus according to any preceding Claim wherein the burners are connected to a common exhaust outlet.

8 Apparatus according to any preceding Claim wherein the or each burner has a third port for the introduction of air.

9. A method of supplying hot air to a user comprising the steps of combusting a combustible fluid in air in a burner having first and second gas ports, discharging the products of said combustion through said first port and conveying them through a regenerator in fluid connection with the burner, and subsequently passing gas through the regenerator and into the burner by said first port and out of the burner to the user by the second port.

10. A method according to Claim 9 wherein the gas subsequently passed through the regenerator comprises air.

11 A method according to Claim 10 wherein the air is contaminated air derived from environs of an industrial process.

12 A method according to any one of Claims 9 to 11 wherein additional air is supplied to the or each burner by a third port.

13 A method according to any one of Claims 9 to 12 wherein the method uses a single burner and the products of combustion continue to be passed through the regenerator after such products have stopped being produced.

14 A method according to any one of Claims 9 to 12 wherein the method employs two burners, and the products of combustion are produced by each in turn with combustion air being introduced through the other.

15 A method according to any one of Claims 9 to 14 wherein the products of combustion, having passed through the regenerator, are discharged to waste.

16 A method according to any one of Claims 9 to 12 or 14 to 15 wherein products of combustion in one burner, having passed through the associated regenerator, are returned to the other burner.

17 Apparatus for the supply of hot air to a user substantially as described with reference to the drawings.

18 A method of employing a regenerative burner to supply hot gas to a user comprising causing the hot products of combustion to issue from the burner towards the regenerator and subsequently passing a gas stream through the regenerator towards the user.

19 A method of supplying hot air to a user substantially as described.

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